LX.—*Observations on the Succession of the Gastropods* Paludestrina ulvæ *and* ventrosa *in Brackish Water*. By G. C. Robson, B.A.

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In the marshes immediately west of Leigh-on-Sea, in Essex, there is a system of tidal ditches in which can be seen a gradual transition from an estuarine to a brackish fauna and flora. Two of the most prolific members of this fauna—the Gastropods *Paludestrina ulvæ* and *ventrosa*—were selected for ecological study in May of the present year, and observations were made upon them periodically until September. In the latter month some of the ditches were cleared out for agricultural or sanitary purposes, and, as a consequence, the observations were discontinued. Although a year's observations are desirable in such cases, certain of the distributional phenomena recorded were so constant and well marked as to justify publication.

Due west of Leigh the first marsh forms a narrow plain between low cliffs and a lateral channel of the Thames known as "Leigh Ray." The marsh appears to be rather lower than the high-tide mark of the river, and is protected from the latter by a high sea-wall.

Inside and parallel to the latter is a ditch about 8–9 feet wide which receives supplies of sea-water at intervals (*v. infra*) through a drain piercing the wall. From this main ditch are given off at right angles a number of secondary ditches, which traverse the marsh and receive a certain amount of surface-drainage. These ditches are obviously artificial, and give the impression that the marsh was at one time either cultivated or used for sewage-disposal. At either end the main ditch bends at right angles and forms two secondary ditches, of which there are six in all. Four of these are in open communication with the main ditch, though they appear to be drying up. The two others were cut off from the main ditch during the period of observation. It is the relation of their fauna and flora to those of the main ditch that is the matter of special interest.

Of the two closed ditches, one—the westernmost of all—was separated by a considerable patch of dry land developing (probably through local elevation) in what was once obviously a continuous channel. The other closed ditch—the fourth

from the west—was separated only by a few feet of dry land rising an inch or so above the water-level at the point of junction.

There can be very little doubt that both these ditches receive water from the main ditch, but only at intervals when the latter has received an exceptionally large supply from the river. It is impossible to be certain whether the main ditch gets filled at *every* high tide and the secondary ditches only at every spring tide, or whether the main ditch is untouched by the neaps and filled by the springs, and the secondary ditches only added to by exceptionally high springs. It is certain, however, that the closed secondary ditches do not receive as much sea-water as the main ditch. Variation in the amount of water in the former, and, as a consequence, in its temperature and salinity, must therefore be more marked in the closed than in the main ditches, at least in the summer and early autumn months.

The fauna and flora of the three ditches is indicated in the following lists. They are by no means exhaustive, but indicate the chief forms or associations observed :—

A. Main ditch (eight stations: May–September):

Nereis diversicolor.
Paludestrina ulvæ (swarming).
—— *ventrosa* (rare).
Alderia modesta.
Limopontia (sc.) *nigra.*
Cardium edule.
Carcinus mœnas.
Gobius sp.
Ulva lactuca.
Vaucheria sp.
Salinity : 2·76 °/₀–2·95 °/₀ NaCl.

B. Westernmost secondary ditch (closed) (four stations: May–September):

Paludestrina ulvæ (very rare indeed, only in August).
—— *ventrosa* (swarming).
Palæmonetes varians.
Carcinus mœnas.
Ruppia maritima (May–July).
Enteromorpha intestinalis (August).
Vaucheria sp. (August).
Salinity : 2·47 °/₀–2·75 °/₀ NaCl.

C. Fourth secondary ditch from west (closed) (four stations: May–September):

Upper end—

Paludestrina ventrosa (swarming).
Ruppia maritima (May–July).
Enteromorpha intestinalis } (August).
Vaucheria sp. }
Salinity: 2·78 %–2·9 % NaCl.

Lower end—

Paludestrina ulvæ (swarming).
—— *ventrosa* (moderately numerous).
Ulva lactuca.
Salinity: 2·78 %–2·95 % NaCl.

From the above lists it will be seen that *Paludestrina ulvæ* appears to be limited to water in which *Ulva* occurs. Stragglers may be found upon other plants (*Enteromorpha intestinalis* and *Schlerochroa maritima*) in this area, but it attains its maximum upon *Ulva*. *P. ventrosa*, on the other hand, appears to be less restricted in its distribution, as it occurs in quite appreciable numbers in all three ditches and upon a variety of plants. It therefore may be reckoned as more plastic and adaptable than *P. ulvæ*, though it undoubtedly thrives in permanently brackish water—an assumption borne out by its absence from typically estuarine faunas.

Attempts were made with artificial sea-water to discover the lowest degree of salinity that *P. ulvæ* would tolerate. For reasons given below it was impossible to arrive at any precise figures, but this much was satisfactorily ascertained—that in water under ·5 % NaCl the animal contracted immediately upon immersion and never emerged from its shell as long as it remained in that water, while in water of 1·0 % NaCl it showed no obvious discomfort upon immersion and, on the whole, behaved very much as it did in higher salinities. Placed in water from C (upper end), from which it is normally absent, it behaved in its ordinary fashion.

In the course of these attempts a curious confirmation was obtained of the view that *P. ventrosa* is more adaptable than *P. ulvæ*. The behaviour of the two animals in captivity is very different. *P. ventrosa* proved itself a very satisfactory subject, as it always remained in the water in which it was placed. *P. ulvæ*, on the other hand, was invariably intractable. It usually crawled out of the water, and, if possible,

out of the vessel containing it, even if the salinity of the water was normal.

It is clear from this account that there must be some factor limiting the distribution of *P. ulvæ* as compared to that of *P. ventrosa*. It is plain that it has the opportunity of getting into the last closed ditch and the upper waters of the fourth ditch, but is never found in the latter and only very rarely in the former. Salinity cannot be the limiting factor, as we have seen that it tolerates low salinities and it also occurs in other places—*e. g.*, the Exe estuary (1)—where it must experience considerable daily alteration in salinity. Temperature need scarcely be considered, as all the ditches are adjacent and very shallow. The main ditch is usually rather deeper than the others; but *P. ulvæ* has been found elsewhere swarming in water as shallow as that of the closed ditches.

On the whole, it seems more likely that the presence or absence of a food-plant is the limiting factor. *P. ulvæ* is not limited to *Ulva lactuca*, as it occurs at Leigh on *Schlerochroa maritima*, on *Ulva*, *Enteromorpha*, and *Zostera* plentifully in the Exe estuary (1), and on *Ulva* and *Zostera* in the Pagham lagoon (Robson MS.). But it is plain that in this area nothing had tempted it out of the *Ulva*-water to colonize in water from which *Ulva* was absent even in August when *Enteromorpha* had replaced *Ruppia*.

One must therefore conclude that *Ulva* is the limiting factor in the present area and that the mollusc has not yet adapted itself to the other available plants, though elsewhere it is not limited to *Ulva lactuca*.

It would be interesting to know if the chief plants of this area show the succession usually found, and so to show that the succession of the two molluscs depended ultimately upon the physical factors determining the distribution of the plants. Unfortunately the minimum salinity which *Ulva lactuca* tolerates is apparently unknown, nor are there apparently any British records for the exact distribution of *Ruppia maritima*. It has been shown that the latter occurs with *Zostera* and apparently *Ulva lactuca* in tidal waters in America (3).

It should also be pointed out that in the main ditch there were signs of pollution (either natural or from sewage), which might easily disturb the ordinary plant succession and account for the fact that in two ditches only differing in a slight degree of salinity there is such a marked difference in the flora. It is well known that *Ulva lactuca* tends to thrive in polluted water (2).

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assistance and information as to local conditions, to Dr. G. F. Prior, F.R.S., for assistance in determining salinity, and to other colleagues for identifying sundry forms enumerated above.

Conclusions.

(1) Ecologically considered *Paludestrina ulvæ* and *P. ventrosa* have distinct areas of distribution, but overlap each other slightly in this area.
(2) This overlapping is due to the greater adaptability of *P. ventrosa*.
(3) *P. ulvæ* appears to be delimited by the presence or absence of food-plants rather than by chemical or physical causes.

Works referred to.

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(2) Corton, A. D. Royal Comm. Sewage Disposal, 7th Report, App. iv. p. 22 (1911).
(3) Johnson, D., and York, H., Johns Hopkins Univ. Circular, 1912.

LXI.—*Note on the Duikers hitherto referred to* Cephalophus maxwelli. By Martin A. C. Hinton.

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In determining some duikers collected recently by Mr. Willoughby P. Lowe on two islands in the estuary of the Rokelle River, Sierra Leone, I have had occasion to examine all the material in the British Museum hitherto referred to *Cephalophus maxwelli*. As a result it would appear, firstly, that the mainland specimens in the collection belong to two distinct species, and, secondly, that the island forms are distinct from each other and from those of the mainland. The characters by which the four species recognized in this paper are distinguished may be tabulated as follows:—

A. Males with relatively large horns; females with horns well developed. Size slightly smaller.
  a. Nasals normal.
    a'. Dorsal pelage not grizzled, uniform dusky; ears without conspicuous